Visional Secret Sharing Technology

[Shijueshi Mimi Fenxiang Jishu]

Po Hsisong, Yang Chinglung

UNITED STATES PATENT AND TRADEMARK OFFICE

Washington, D.C. October 2004

Translated by: Schreiber Translations, Inc.

Translated Title	:	Visional Secret Sharing Technology
Foreign Title	:	Shijueshi Mimi Fenxiang Jishu
Authors	:	Po Hsisong, Yang Chinglung
Author Affiliation	:	Department of Electrics, National Chengkung University
Source	:	Patent Gazette of Republic of China

Visional Secret Sharing Technology

Shijueshi Mimi Fenxiang Jishu

Po Hsisong, Yang Chinglung

[57] Scope of Patent in Application

This patent concerns:

1. A (k,n) visional secret sharing method that can detect errors and counterfeit transparencies, wherein k, n are positive integrals. The method includes:

Providing $n \times m$ shared matrixes Sw and Sb representing white and black pixels in the (k,n) visional secret sharing method;

Expanding the $n \times m$ shared matrixes Sw and Sb into four $(n+1)\times(m+2)$ shared matrixes Sww, Swb, Sbw, and Sbb:

$$Sww = \left[\begin{array}{c|c} \underline{10} & \underline{0\cdots0} \\ 10 & \\ \vdots & Sw \\ 10 & \end{array}\right] \qquad Swb = \left[\begin{array}{c|c} \underline{10} & \underline{0\cdots0} \\ 10 & \\ \vdots & Sb \\ 10 & \end{array}\right]$$

[1] Numbers in the margin indicate pagination in the foreign text.

$$Sbw = \left[\begin{array}{c|c} \underline{10} & \underline{0\cdots0} \\ 10 & \\ \vdots & Sw \\ 10 & \end{array}\right] \qquad Sbb = \left[\begin{array}{c|c} \underline{10} & \underline{0\cdots0} \\ 10 & \\ \vdots & Sb \\ 10 & \end{array}\right], \text{ and}$$

based on the four $(n+1)\times(m+2)$ shared matrixes Sww, Swb, Sbw, Sbb, dividing a secret image comprised of multiple pixels into $n+1$ sheets of transparency, whereas each pixel in the secret image corresponds to $m-2$ small pixels, whereas shared matrix Sww is applied when the pixels in the secret image and in an examining image are all white, whereas shared matrix Swb is applied when the pixels in the secret image are white and the pixels in the examining image are black, whereas shared matrix Sbw is applied when the pixels in the secret image are black and the pixels in the examining image are white, whereas shared matrix Sbb is applied when the pixels in the secret image and in an examining image are all black;

As a result, the formed 1st transparency can be used for detecting errors and counterfeit transparencies. The examining image can be obtained from superimposition of the first transparency with other transparences. The secret image can be obtained from superimposition of any k sheets of transparency from other n transparencies.

2. A (k,n) visional secret sharing method that can detect errors and counterfeit transparencies, wherein k, n are positive integrals, and $k \geq 3$. The method includes:

Providing $n \times m$ shared matrixes Sw and Sb representing white and black pixels in the (k,n) visional secret sharing method;

/544

Expanding the $n \times m$ shared matrixes Sw and Sb into four $n \times [m + n \times (n-1)]$ shared matrixes Sww, Swb, Sbw, and Sbb:

$$Sww = \left[\begin{array}{c|c} \begin{matrix} 1010 \cdots 11 \\ 1011 \cdots \vdots \\ 1010 \cdots \vdots \\ \vdots 11 \cdots 11 \\ \vdots \; \vdots \cdots 10 \\ 1111 \cdots 10 \end{matrix} & Sw \end{array} \right] \qquad Swb = \left[\begin{array}{c|c} \begin{matrix} 1010 \cdots 11 \\ 1011 \cdots \vdots \\ 1010 \cdots \vdots \\ \vdots 11 \cdots 11 \\ \vdots \; \vdots \cdots 10 \\ 1111 \cdots 10 \end{matrix} & Sb \end{array} \right]$$

$$Sbw = \left[\begin{array}{c|c} \begin{matrix} 1010 \cdots 11 \\ 0111 \cdots \vdots \\ 1001 \cdots \vdots \\ \vdots 11 \cdots 11 \\ \vdots \; \vdots \cdots 10 \\ 1111 \cdots 01 \end{matrix} & Sw \end{array} \right] \qquad Sbb = \left[\begin{array}{c|c} \begin{matrix} 1010 \cdots 11 \\ 0111 \cdots \vdots \\ 1001 \cdots \vdots \\ \vdots 11 \cdots 11 \\ \vdots \; \vdots \cdots 10 \\ 1111 \cdots 01 \end{matrix} & Sb \end{array} \right]$$

based on the four $n \times [m + n \times (n-1)]$ shared matrixes Sww, Swb, Sbw, Sbb, dividing a secret image comprised of multiple pixels

into n sheets of transparency, whereas each pixel in the secret image corresponds to $m+n\times(n-1)$ small pixels, whereas shared matrix Sww is applied when the pixels in the secret image and in an examining image are all white, whereas shared matrix Swb is applied when the pixels in the secret image are white and the pixels in the examining image are black, whereas shared matrix Sbw is applied when the pixels in the secret image are black and the pixels in the examining image are white, whereas shared matrix Sbb is applied when the pixels in the secret image and in an examining image are all black;

As a result, the superimposition of any two transparencies from the above-mentioned n transparencies can be used for detecting errors and counterfeit transparencies, and obtaining the examining image. The secret image can be obtained from superimposition of any k sheets of transparency from other n transparencies.

3. A ($1\rightarrow n$) visional secret sharing method that can sequentially shared $n-1$ sheets of secret images, detect errors and counterfeit transparencies, wherein k, n are positive integrals, and $k\geq 3$. The method includes:

Providing $u \times 2^{u-1}$ shared matrixes Sw and Sb representing white and black pixels in the (u,u) visional secret sharing method;

Assuming the $u \times 2^{u-1}$ shared matrixes $Sw^{(1-1)}$ and $Sb^{(1-1)}$ as [0] and [1], and obtaining 2^u shared matrixes in regression manner;

$$S_{ww}^{(1\to u+1)} = \left[\begin{array}{c|c} S_w^{(u+1,u-1))} & \begin{array}{c} 1\cdots 1 \\ \\ S_w^{(1-u)} \end{array} \end{array}\right] \qquad S_{wb}^{(1\to u+1)} = \left[\begin{array}{c|c} S_w^{(u+1,u-1))} & \begin{array}{c} 1\cdots 1 \\ \\ S_b^{(1-u)} \end{array} \end{array}\right]$$

$$S_{bw}^{(1\to u+1)} = \left[\begin{array}{c|c} S_b^{(u+1,u-1))} & \begin{array}{c} 1\cdots 1 \\ \\ S_w^{(1-u)} \end{array} \end{array}\right] \qquad S_{bb}^{(1\to u+1)} = \left[\begin{array}{c|c} S_b^{(u+1,u-1))} & \begin{array}{c} 1\cdots 1 \\ \\ S_b^{(1-u)} \end{array} \end{array}\right];$$

n sheets of transparencies can be obtained through transformation of the 2^u shared matrixes, whereas shared matrix Sww is applied when the pixels in the first secret image are white and the pixels in the second secret image are white……, whereas shared matrix Swb is applied when the pixels in the first secret image are white and the pixels in the second secret image are black……, whereas shared matrix Sbw is applied when the pixels in the first secret image are black and the pixels in the second secret image are white……, whereas shared matrix Sbb is applied when the pixels in the first secret image are black and the pixels in the second secret image are black…, and so on.

As a result, the first secret image can be obtained through superimposition of the 1^{st}~2^{nd} transparencies, the second secret image can be obtained through superimposition of the 1^{st}~3^{rd} transparencies, and so on.

4. A color (k,k) visional secret sharing method that can conduct secret sharing to c-color secret images, wherein k is positive integral. The method includes:

Providing $k \times 2^{k-1}$ shared matrixes B_0 and B_1 representing white pixels and black pixels in the black-white (k,k) visional secret sharing method, wherein the numbers of "1" in each column element are all even and odd numbers;

Extending the shared matrixes B_0 and B_1 to c number of $k \times (c \times 2^{k-1})$ shared matrixes C_i:

(*translator's note: formula not legible*)

Based on the c number of $k \times (c \times 2^{k-1})$ shared matrixes, transforming a color secret image comprised of multiple pixels into k number of transparencies. In this secret image, each pixel corresponds to $c \times (2^{k-1})$ number of small pixels. Shared matrix C_0 is applied when the pixels of the color secret image are color 0 pixels; Shared matrix C_1 is applied when the pixels of the color secret image are color 1 pixels……, and so on.

As a result, the color secret image can be obtained from superimposition of k sheets of transparencies.

/545

5. A color (k,n) visional secret sharing method that can conduct secret sharing to c-color secret images, wherein k and n are positive integrals. The method includes:

Providing $n \times m$ shared matrixes B_0 and B_1 representing white pixels and black pixels in the black-white (k,n) visional secret sharing method;

Extending the shared matrixes B_0 and B_1 to c number of $n \times (c \times m)$ shared matrixes C_i:

(*translator's note: formula not legible*)

Based on the c number of $n \times (c \times m)$ shared matrixes, transforming a color secret image comprised of multiple pixels into n number of transparencies. In this secret image, each pixel corresponds to $c \times m$ number of small pixels. Shared matrix C_0 is applied when the pixels of the color secret image are color 0 pixels; Shared matrix C_1 is applied when the pixels of the color secret image are color 1 pixels……, and so on.

As a result, the color secret image can be obtained from superimposition of any k sheets of transparencies from the above-mentioned k transparencies.

6. A visional secret sharing method as described in Claims 1, 2, 3, 4, or 5, whereas the transparencies can be stored and superimposed by a computer image editing software.

7. A visional secret sharing method as described in Claim 6, whereas the transparencies can be put in both the host and client computers of a network system for identifying purpose and preventing illegal users to enter the system.

8. A visional secret sharing method as described in Claim 6, whereas the transparencies can be made into a goggles to be placed in front of the computer screen.

9. A visional secret sharing method as described in Claim 6, whereas the transparencies can be made into a thin film to cover on the LCD of a mobile phone set.

10. A visional secret sharing method as described in Claim 4, the columns having "*" (representing black color) in the whole column in the shared matrix C_i can be deleted so as to further reduce the shared length b to:

$b = c \times 2^{k-1} - 1$ (when c is an even number), and

$b = c \times 2_{k-1} - c + 1$ (when c is an odd number).

Brief Explanations to Drawings:

Fig. 1A ~ Fig. 1C are illustrations of application of the known visional secret sharing technology in the Internet;

Fig. 2 is an illustration of application of the known visional secret sharing technology in mobile phones;

Fig. 3 is an illustration of the known (k,n) visional secret sharing technology;

Fig. 4A is an image (the first secret image) obtained through superimposition of the 1st shared image with other shared images as described in Implementation 1 of this invention;

Fig. 4B is an image (the second secret image) obtained through superimposition of any two shared images from the 2nd, 3rd, 4th, and 5th shared images as described in Implementation 1 of this invention;

Fig. 5A is an illustration of the 1st shared image as described in Implementation 3 of this invention;

Fig. 5B is an illustration of the image (the first secret image) obtained through superimposition of the 1st shared image and the 2nd shared image as described in Implementation 3 of this invention;

Fig. 5C is an illustration of the image (the second secret image) obtained through superimposition of the 1st shared image,

the 2nd shared image, and the 3rd shared image as described in Implementation 3 of this invention;

Fig. 6A and Fig. 6B are illustrations of pixels in known color VSS technology;

Fig. 7A and Fig. 7B are illustrations of pixels in color VSS technology as described in Implementation 4 of this invention;

Fig. 8A is an illustration of colors of single shared image as described in Implementation 4 of this invention;

Fig. 8B is an illustration of colors of the image after superimposition of any two shared images as described in Implementation 4 of this invention;

Fig. 8C is an illustration of colors of the image after superimposition of any three shared images as described in Implementation 4 of this invention;

Fig. 9A ~ Fig. 9D are comparisons in computer expression between the color VSS technology in this invention and the known color VSS technology.

/546

******

******

Fig. 1A

******

******

Fig. 1B

******

******

Fig. 1C

/547

******

******

Fig. 2

******

******

Fig. 3

/548

******

******

Fig. 4A

******

******

Fig. 4B

******

******

Fig. 5A

/549

******

******

Fig. 5B

******

******

Fig. 5C

******

******

Fig. 6A

******

******

Fig. 6B

/550

******

******

Fig. 7A

******

******

Fig. 7B

******

******

Fig. 8A

******

******

Fig. 8B

中 華 民 國 專 利 公 報 〔19〕〔12〕

〔11〕公告編號：364957

〔44〕中華民國88年（1999）07月21日

發明 全 10 頁

〔51〕Int·Cl⁶：G06F11/00
G09C1/00

〔54〕名 稱：視覺式秘密分享技術

〔21〕申 請 案 號：87102660 〔22〕申請日期：中華民國87年（1998）02月24日

〔72〕發 明 人：
賴溪松 台南市大學路一號（國立成功大學電機系）
楊慶隆 高雄市自由二路六巷五十七號

〔71〕申 請 人：
賴溪松 台南市大學路一號（國立成功大學電機系）

〔74〕代 理 人：洪澄文 先生

[57]申請專利範圍：

1.一種可偵測錯誤及偽造投影片之(k，n)視覺式秘密分享方法，其中，k，n為正整數，包括：

提供一(k，n)視覺式秘密分享方法中表示白色及黑色像素之n×m分享矩陣Sw及Sb；

將該些n×m分享矩陣Sw及Sb擴展為四個(n＋1)×(m＋2)分享矩陣Sww、Swb、Sbw及Sbb；以及

$$S_{ww}=\left[\begin{array}{cc|c}1&0&0\cdots0\\\hline 1&0&\\\vdots&\vdots&S_w\\1&0&\end{array}\right]\qquad S_{wb}=\left[\begin{array}{cc|c}1&0&0\cdots0\\\hline 1&0&\\\vdots&\vdots&S_b\\1&0&\end{array}\right]$$

$$S_{bw}=\left[\begin{array}{cc|c}1&0&0\cdots0\\\hline 1&0&\\\vdots&\vdots&S_w\\1&0&\end{array}\right]\qquad S_{bb}=\left[\begin{array}{cc|c}1&0&0\cdots0\\\hline 1&0&\\\vdots&\vdots&S_b\\1&0&\end{array}\right]$$

根據該四個(n＋1)×(m＋2)分享矩陣Sww、Swb、Sbw及Sbb將一由複數像素組成之秘密影像分成n＋1張投影片且該秘密影像中各像素係對應m－2個小像素，其中，分享矩陣Sww在該秘密影像及一檢查影像之像素均為白色時使用，分享矩陣Swb在該秘密影像之像素為白色且該檢查影像之像素為黑色時使用，分享矩陣Sbw在該秘密影像之像素為黑色且該檢查影像之像素為白色時使用，而分享矩陣Sbb則在該秘密影像及該檢查影像之像素均為黑色時使用；

是以，形成之第1張投影片可做為偵測錯誤及偽造投影片之用，其與各別投影片重疊可得該檢查影像，而其他n張投影片中任k張投影片重疊則可得到該秘密影像。

2.一種可偵測錯誤及偽造投影片之(k，n)視覺式秘密分享方法，其中，k，n為正整數，且k≥3，包括：

提供一(k，n)視覺式秘密分享方法中表示白色及黑色像素之n×m分享矩陣Sw及Sb；

將該些 n × m 分享矩陣 Sw 及 Sb 擴展為四個 n × [m + n × (n-1)] 分享矩陣 Sww、Swb、Sbw 及 Sbb；以及

$$Sww=\left[\begin{array}{c|c}\begin{matrix}1010\cdots11\\1011\cdots\vdots\\1010\cdots\vdots\\\vdots\ 11\cdots11\\\vdots\ \vdots\cdots10\\1111\cdots10\end{matrix} & Sw\end{array}\right]\qquad Swb=\left[\begin{array}{c|c}\begin{matrix}1010\cdots11\\1011\cdots\vdots\\1010\cdots\vdots\\\vdots\ 11\cdots11\\\vdots\ \vdots\cdots10\\1111\cdots10\end{matrix} & Sb\end{array}\right]$$

$$Sbw=\left[\begin{array}{c|c}\begin{matrix}1010\cdots11\\0111\cdots\vdots\\1001\cdots\vdots\\\vdots\ 11\cdots11\\\vdots\ \vdots\cdots10\\1111\cdots01\end{matrix} & Sw\end{array}\right]\qquad Sbb=\left[\begin{array}{c|c}\begin{matrix}1010\cdots11\\0111\cdots\vdots\\1001\cdots\vdots\\\vdots\ 11\cdots11\\\vdots\ \vdots\cdots10\\1111\cdots01\end{matrix} & Sb\end{array}\right]$$

根據該四個 n × [m + n × (n-1)] 分享矩陣 Sww、Swb、Sbw 及 Sbb 將一由複數像素組成之秘密影像分成 n 張投影片且該秘密影像中各像素係對應 m + n × (n-1) 個小像素，其中，分享矩陣 Sww 在該秘密影像及一檢查影像之像素均為白色時使用，分享矩陣 Swb 在該秘密影像之像素為白色且該檢查影像之像素為黑色時使用，分享矩陣 Sbw 在該秘密影像之像素為黑色且該檢查影像之像素為白色時使用，而分享矩陣 Sbb 則在該秘密影像及該檢查影像之像素均為黑色時使用；

是以，上述 n 張投影片中任兩張投影片重疊可用以偵測錯誤及偽造之投影片並得到該檢查影像，而上述 n 張投影片中任 k 張投影片重疊則可得到該秘密影像。

3. 一種(1→n)視覺式秘密分享方法，可依序分享 n-1 張秘密影像，其中，k，n 為正整數，包括：

提供(u，u)視覺式秘密分享方法中表示表示白色及黑色像素之 $u \times 2^{u-1}$ 分享矩陣 Sw 及 Sb；

將該些 $u \times 2^{u-1}$ 分享矩陣 $Sw^{(1\to 1)}$ 及 $Sb^{(1\to 1)}$，設為[0]及[1]，並以遞迴方式得到 2^u 個分享矩陣：

$$S_{ww\cdots}^{(1\to u+1)}=\left[S_w^{(u+1,u+1)}\left|\begin{matrix}1\cdots1\\ \\ S_{w\cdots}^{(1\to u)}\end{matrix}\right.\right]\qquad S_{wb\cdots}^{(1\to u+1)}=\left[S_w^{(u+1,u+1)}\left|\begin{matrix}1\cdots1\\ \\ S_{b\cdots}^{(1\to u)}\end{matrix}\right.\right]$$

$$S_{bw\cdots}^{(1\to u+1)}=\left[S_b^{(u+1,u+1)}\left|\begin{matrix}1\cdots1\\ \\ S_{w\cdots}^{(1\to u)}\end{matrix}\right.\right]\qquad S_{bb\cdots}^{(1\to u+1)}=\left[S_b^{(u+1,u+1)}\left|\begin{matrix}1\cdots1\\ \\ S_{b\cdots}^{(1\to u)}\end{matrix}\right.\right]$$

根據該 2^u 個分享矩陣轉換以得到 n 張投影片，其中，分享矩陣 Sww... 在一第一秘密影像之像素為白色，一第二秘密影像之像素為白色，...時使用，分享矩陣 Swb... 在該第一秘密影像之像素為白色，該第二秘密影像之像素為黑色，...時使用，分享矩陣 Sbw... 在該第一秘密影像之像素為黑色，該第二秘密影像之像素為白色，...時使用，分享矩陣 Sbb... 在該第一秘密影像為黑色，該第二秘密影像之像素為黑色，...時使用，餘以此類推；

如此，第 1～2 張投影片重疊可得到該第一秘密影像，第 1～3 張投影片重疊可得到該第二秘密影像，餘以此類推。

4. 一種彩色(k，k)視覺式秘密分享方法，可對 c 色秘密影像進行秘密分享，其中，k 為正整數，包括：

提供一黑白(k，k)視覺式秘密分享方法中表示白色像素及黑色像素之 $k \times 2^{k-1}$ 分享矩陣 B_0 及 B_1，其各欄元素中 "1" 的數目均為偶數及奇數；

根據該些分享矩陣 B_0 及 B_1 延伸為 c 個 $k \times (c \times 2^{k-1})$ 分享矩陣 Ci，其中

$$C_i=\left[\cdots\left|B^{(\cdots)}\right|B^{(\cdots)}\left|B^{(\cdots)}\right|\cdots\left|B^{(\cdots)}\right|\cdots\right]$$
$$\text{where } i\in\{0,1,\ldots,c-1\} \text{ and } j_i\in\{0,1,\ldots,c-1\}-\{i\}$$

根據該 c 個 $k \times (c \times 2^{k-1})$ 分享矩陣將一由複數像素組成之彩色秘密影像轉換成 k 張投影片且該秘密影像中各像素係對應 $c \times (2^{k-1})$ 個小像素，其中，分享矩陣 C_0 在該彩色秘密影像之像素為第 0 顏色時使用，分享矩陣 C_1 在該彩色秘密影像之像素為第 1 顏色時使用，...，餘以此類推；

如此，當 k 張投影片重疊時便可得到該彩色秘密影像。

5.一種彩色(k，n)視覺式秘密分享方法，可對c色秘密影像進行秘密分享，其中，n，k為正整數，包括：
提供一黑白(k，n)視覺式秘密分享方法中表示白色像素及黑色像素之n×m分享矩陣B_0及B_1；
根據該些分享矩陣B_0及B_1延伸為c個n×(c×m)分享矩陣Ci，其中

$$C_i = \{ \text{[illegible]} \} \quad \text{where } i \in \{0,1,\ldots,c-1\} \text{ and } j_i \in \{0,1,\ldots,c-1\}-\{i\}$$

根據該c個n×(c×m)分享矩陣將一由複數像素組成之彩色秘密影像轉換成n張投影片且該秘密影像中各像素係對應c×m個小像素，其中，分享矩陣C_0在該彩色秘密影像之像素為第0顏色時使用，分享矩陣C_1在該彩色秘密影像之像素為第1顏色時使用，...，餘以此類推：
如此，當上述n張投影片中任何k張投影片重疊後便可以得到該彩色秘密影像。

6.如申請專利範圍第1、2、3、4或5項所述之視覺式秘密分享方法，其中，該些投影片亦可以電腦影像編輯軟體儲存並且進行重疊成像的工作。

7.如申請專利範圍第6項所述之視覺式秘密分享方法，其中，該些投影片可分別置網路系統之主機端及客戶端，藉以進行辨證並防止非法使用者進入。

8.如申請專利範圍第6項所述之視覺式秘密分享方法，其中，該些投影片可製成一護目鏡，置於電腦螢幕前方。

9.如申請專利範圍第6項所述之視覺式秘密分享方法，其中，該些投影片可製成一薄膜，覆蓋於行動電話手機之液晶顯示螢幕上。

10.如申請專利範圍第4項所述之彩色視覺式秘密分享方法，其中，該些分享矩陣Ci中具有整列"•"(表示黑色)之欄位可予以刪除，進而使分享長度b進一步縮小至
$b = c \times 2^{k-1}-1$(當c為偶數)，以及
$b = c \times 2_{k-1}-c+1$(當c為奇數)。

圖式簡單說明：

第一圖A～第一圖C係習知視覺式秘密分享技術應用於網際網路之示意圖；

第二圖係習知視覺式秘密分享技術應用於行動電話手機之示意圖；

第三圖係習知(k，n)視覺式秘密分享技術之示意圖；

第四圖A係本發明例1中第1張分享影像與其他分享影像重疊所得之影像(即第一秘密影像)；

第四圖B係本發明例1中第2，3，4，5張分享影像中任兩張分享影像重疊後所得之影像(即第二秘密影像)；

第五圖A係本發明例3中第1張分享影像之示意圖；

第五圖B係本發明例3中第1張分享影像及第2張分享影像重疊後所得結果(第一秘密影像)之示意圖；

第五圖C係本發明例3中第1張分享影像、第2張分享影像及第3張分享影像重疊後所得結果(第二秘密影像)之示意圖；

第六圖A及第六圖B係習知彩色VSS技術中各像素之示意圖；

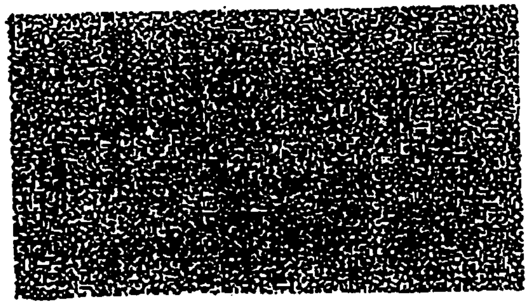
第七圖A及第七圖B係本發明實施例四中彩色VSS技術中各像素之示意圖；

第八圖A係本發明例4中單張分享影像之顏色示意圖；

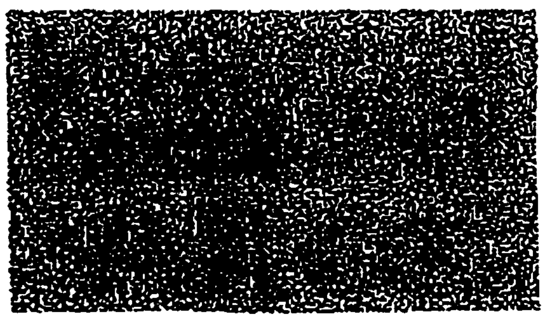
第八圖B係本發明例4中任兩張分享影像重疊後之顏色示意圖；

第八圖C係本發明例4中三張分享影像重疊後之顏色示意圖；以及

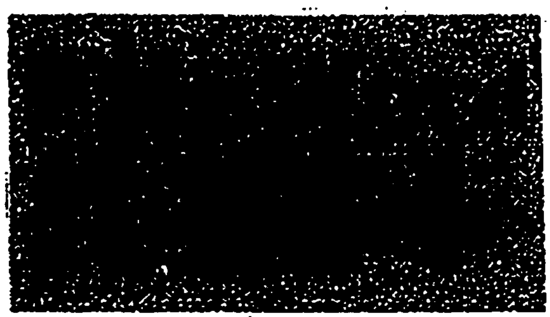
第九圖A～第九圖D係本發明彩色VSS技術與習知彩色VSS技術在電腦中表示法之比較。



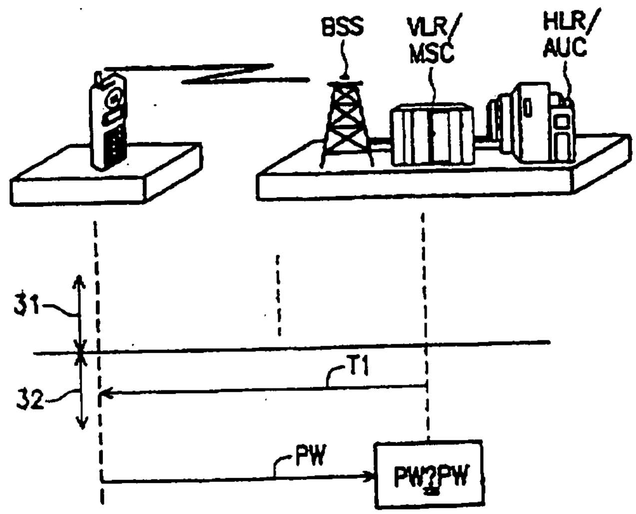
第一圖 A

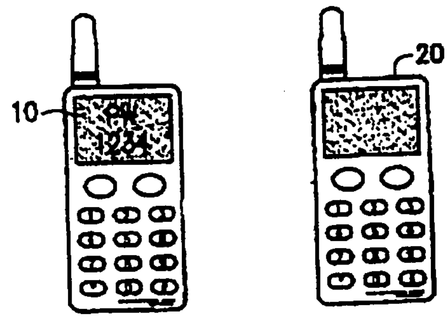


第一圖 B

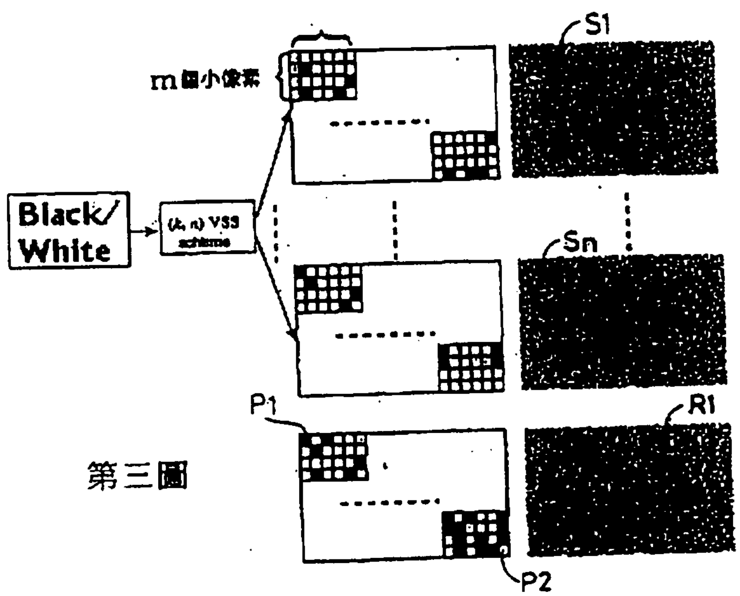


第一圖 C

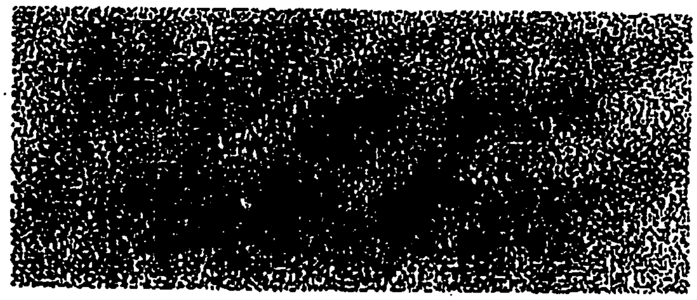

BSS
VLR/
MSC
HLR/
AUC
31
32
T1
PW


10
20

第二圖


m個小像素
S1
Black/
White
Sn
P1
R1
P2

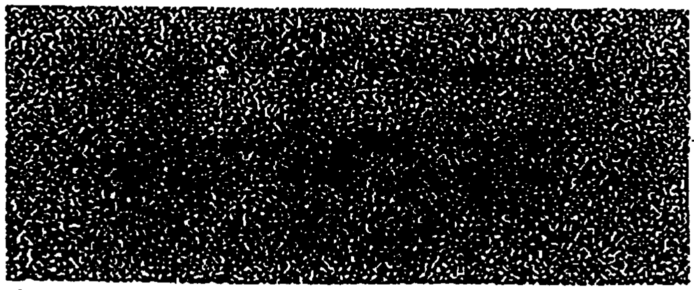
第三圖



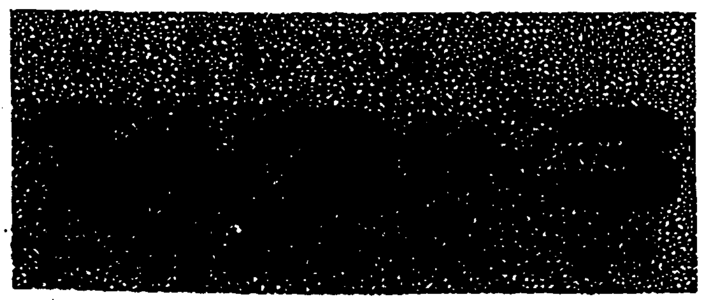
第四圖 A

第四圖 B

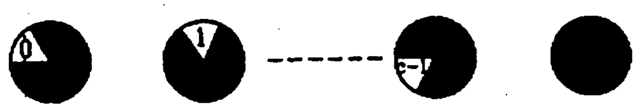
第五圖 A



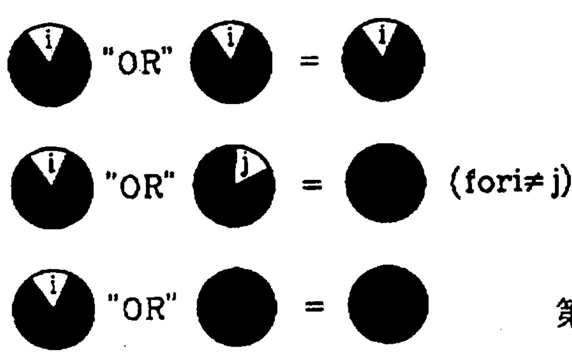
第五圖B



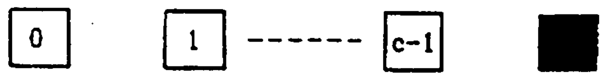
第五圖C



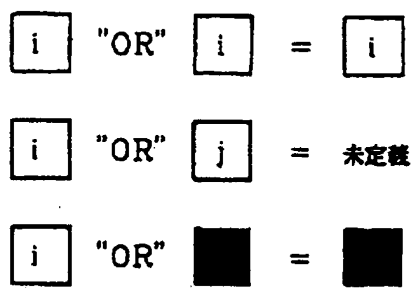
第六圖A



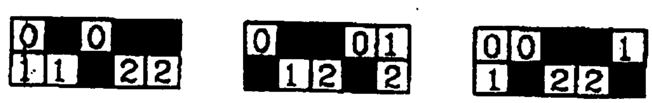
第六圖B



第七圖 A



第七圖 B



第八圖 A

第八圖 B